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The Dutch Open Telescope

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Abstract. The Dutch Open Telescope is a new and novel optical solar telescope on La Palma. It aims at high resolution by combining an excellent site on La Palma with an open tower and an open telescope and leads the way to large-aperture high resolution telescopes. We briefly review the DOT principle, structure and goals. More information is found at the DOT website[1].

1. Introduction

The Dutch Open telescope (DOT) has grown out of the open telescope concept envisioned by C. Zwaan and R.H. Hammerschlag in the seventies. It has been pretty much a two-man project (Hammerschlag and technician P.W. Hoogendoorn) through the years. Its progress accelerated from a substantial grant by the Dutch technology foundation (STW) covering the completion and installation at La Palma – where the DOT now stands close to the Swedish Solar Vacuum Telescope (SVST), on top of its stilts as if a Martian invader has descended straight out of H.G. Wells' "The War of the Worlds". Its first images demonstrated its potential for high-resolution solar physics (Fig. 1).

Recently, between the meeting and the writeup of this poster presentation, funding has been allocated for a three-year "science validation" period in which we get the chance to demonstrate the DOT capabilities for optical solar physics. To a large extent, the future of solar physics in The Netherlands rides on this demonstration.

2. DOT principle

The DOT is a reflector with a parabolic mirror that sits out in the open at a height of 17 m (Fig. 1). The open design departs radically from existing solar telescopes. All current high-resolution telescopes rely on internal evacuation to avoid internal turbulence. Examples are reflectors such as the NSO 76 cm Dunn Telescope at Sacramento Peak, the German 70 cm VTT at Tenerife, the French-Italian 90 cm THEMIS at Tenerife, and refractors such as the Swedish 47 cm SVST on La Palma. The vacuum window (reflectors) or the objective lens (refractors) sets a restrictive size limit of about 100 cm which does not apply to

[1] http://www.astro.uu.nl/~rutten/dot

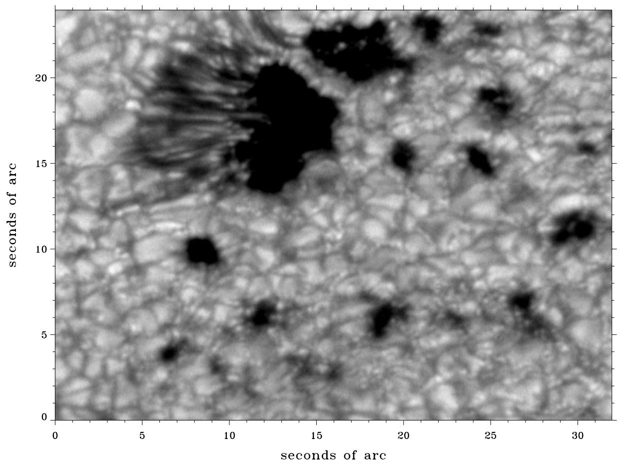

Figure 1. Top: the DOT on La Palma, December 5, 1997. North is to the right. Bottom: wide-band continuum image of an active region taken with the DOT on December 5, 1997.

open telescopes. Thus, the DOT represents an important test for large solar telescope concepts. The current DOT aperture is 45 cm, but the mechanical structure accepts a 76 cm mirror without change, a 100 cm mirror with minor adaptation, a yet larger mirror with major modification.

The telescope and the support tower are both open. There is no dome, only a fold-away bad-weather canopy. This novel design exploits the often excellent La Palma conditions through posing minimal obstruction to the strong trade winds that bring the best seeing. At La Palma, the best daytime seeing tends to occur when strong winds (5–10 m/s) from Northern directions suppress the convective plumes that arise from local ground heating. When the wind is sufficiently strong it confines the boundary convection to a thin layer of only about 10 m, well below the DOT telescope height of 17 m. This extraordinary circumstance may last all day and makes La Palma intrinsically better than all US mountain sites, where good seeing occurs just briefly after sunrise, before the convection starts and produces turbulence in a layer many tens of meters thick. (Comparable quality is reached at Pic du Midi after snowfall in summer, not a frequent event.)

Thus, the DOT's principle is to minimize obstruction to the local air flow. It also relies on the same strong winds, blowing right through the telescope, to inhibit convective turbulence within the telescope and in its immediate surroundings.

In addition, the simple optical scheme of the DOT guarantees optimum performance by avoiding the severe alignment problems that come with more complex arrangements such as Gregorian designs. The extraordinary mechanical stability gives high pointing precision even in strong winds. The fold-away canopy survives even the severe La Palma winter storms and ice loads.

3. DOT structure

The primary mirror (Cervit, 45 cm diameter, focal length 200 cm) focuses the incoming beam onto a water-cooled diaphragm that reflects most of the solar image out of the telescope and transmits only a 2 by 2 arcmin subfield.

The mirror is mounted deformation-free with nine-point axial and three-point radial support in a parallactic telescope structure that is considerably overdimensioned as well as unbalanced in order to obtain extreme pointing stability. Brushless pairs of servo motors in push-pull preload configuration without backlash drive four-step gear trains achieving 1:75,000 reduction with self-aligning gears. The extreme reduction serves to drive the telescope at very low dissipation (only about 20 W) in order to avoid local heat sources.

The 15 m DOT support tower puts the telescope above the turbulent boundary layer, especially when the strong trade wind blows upslope from Northern directions in the best-seeing weather pattern. The tower consists of eight triangularly arranged steel-tube stilts. The configuration permits only lateral motion of the platform, inhibiting any tilt with respect to the incoming wavefront, so that the telescope maintains precise angular tracking even in strong wind buffeting. At 13 tons the tower is considerably lighter than the combined platform (5 tons) and telescope (17 tons) which it supports. Nevertheless, it is designed to withstand large ice loads and (simultaneous) wind pressure.

The bad-weather enclosure opens clam-like and folds away to the sides. It is made of heavy polyester fabric mounted on heavy steel ribs and may be closed in winds up to 30 m/s (or opened, less likely). When closed it should withstand the 70 m/s (Bf 12) winds that might hit Roque de los Muchachos in the harsh La Palma winter storms. The coated surface tends to remain ice-free.

4. DOT goals

The DOT is intended for imaging the solar photosphere and chromosphere with high spatial resolution. Resolution is the key frontier in optical solar physics. A major quest is to locate, diagnose and follow the basic elements of the solar magnetic field.

The three-year initial science program aims to obtain simultaneous imaging in three diagnostics:

- G band: field topology in the photosphere;
- Ca II K: field topology in the lower chromosphere;
- Hα: field topology in the upper chromosphere.

At present, simple secondary optics is mounted along the telescope axis in a tube behind prime focus (Fig. 1). A G-band camera will be placed there, while filtergrams in Ca II K and Hα will be taken with cameras mounted besides the incoming beam.

These three imagers will serve as "proxy-magnetographs" in support of studies with space-based instrumentation (SOHO and TRACE). The program does not only follow techniques pioneered by G. Scharmer at the SVST, but it will actually rely on SVST hardware and software and on DOT operation from the SVST building. This will make it easy to operate the two telescopes in tandem. The program aims to chart and track the magnetic field patterns in the solar photosphere and chromosphere. In the meantime, we hope to develop instrumentation for future Stokes vector magnetometry and to implement advanced image processing to improve on the remaining seeing. These efforts are part of the European Solar Magnetometry Network[2].

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[2]http://www.astro.uu.nl/~rutten/tmr